ABSTRACTS BOOKLET

Seventeenth Annual
Pikes Peak Regional
Undergraduate Mathematics Conference

Colorado State University - Pueblo
Saturday, February 22, 2020
# Table of Contents

Keynote Address ....................................................................................................................... 1

Student Presentations

- Jared Bressler ...................................................................................................................... 3
- Ryan Chen ........................................................................................................................... 3
- Samuel Cho .......................................................................................................................... 3
- Staci Davis .......................................................................................................................... 3
- Charles Filippone .............................................................................................................. 4
- Tatiana Finley ..................................................................................................................... 4
- Margaret Knight .................................................................................................................. 4
- Samuel LeBlanc ................................................................................................................... 4
- Kristen Ochle and Heidi Staggs ......................................................................................... 5
- Edgar Santos ....................................................................................................................... 5
- Lauren Stierman .................................................................................................................. 5
- Hudson Tompkins .............................................................................................................. 6
- Christopher Toomey .......................................................................................................... 6
- Jim Wang ............................................................................................................................ 6
- Joshua Yauney .................................................................................................................... 6

Acknowledgements ................................................................................................................ Back Cover
Keynote Address

Dr. Katie Morrison
University of Northern Colorado

Graphs, Neural Networks, and Emergent Dynamics in the Brain

Networks of neurons in the brain often exhibit complex patterns of activity that are shaped by the intrinsic structure of the network. For example, spontaneous sequences of neural activity have been observed in cortex and hippocampus, and patterned motor activity arises in central pattern generators for locomotion. In this talk, we will begin with an introduction to some of the neuroscience phenomena informing our work, and then focus on a simplified neural network model known as Combinatorial Threshold-Linear Networks (CTLNs) in order to understand how the pattern of neural connectivity shapes the resultant neural activity. Specifically, the connectivity of these networks is encoded in a directed graph, and we will develop a series of graph rules characterizing how the graph structure shapes the neural dynamics by way of controlling the stable and unstable fixed points of the network.

Speaker Biography

Dr. Katie Morrison is an Associate Professor in the School of Mathematical Sciences at University of Northern Colorado. She received her BA from Swarthmore College, double majoring in mathematics and psychology, and her PhD in mathematics from the University of Nebraska. Her dissertation work was in algebraic coding theory, but she has since transitioned into mathematical neuroscience. Dr. Morrison’s current research focuses on the mathematical theory and analysis of neural networks and neural codes, using tools from algebra, discrete mathematics, and topology.
Student Presentations

Except where otherwise noted, the affiliations of the faculty sponsors are the same as that of the speakers.

Jared Bressler
Colorado State University - Pueblo
Faculty Sponsor: Dr. Bruce Lundberg

*Least Square Regression with Bounded Missing Data*

My talk considers a least squares model arising in the area of labor statistics which by policy must have missing data entries in its design matrix. The sum of the missing entries is, however, constrained by other available data. I use this and other constraints to produce error bounds on both the regression coefficients and residual vectors. I use these error bounds to inform the construction and interpretation of prediction/confidence intervals, t-tests and ANOVA analysis of the model.

Ryan Chen
United States Air Force Academy
Faculty Sponsor: Dr. Kurt Herzinger

*The Game of “Destroy the Graph”*

“Destroy the Graph” is a 2-player game, played on a directed graph, inspired by the game of Sylver Coinage. Players take turns choosing vertices and destroying all vertices along a directed path. The player that destroys the graph is the winner. In this talk, we will examine winning and losing positions in this game. We will focus on graphs of specific configurations such as “star graphs,” “double stars,” and “sequential constellations.”

Samuel Cho
United States Air Force Academy
Faculty Sponsor: Dr. Kurt Herzinger

*The Basics of Sylver Coinage and Numerical Semigroups*

A numerical semigroup is a sub-monoid of the non-negative integers, with a finite complement. In this talk, we will examine various aspects and questions relating to numerical semigroups. In particular, we will relate numerical semigroups to the two-player game, Sylver Coinage, introduced by John Conway and named after J.J. Sylvester.

Staci Davis
United States Air Force Academy
Faculty Sponsor: Dr. Kurt Herzinger

*The Game of Sylver Coinage*

The Game of Sylver Coinage is a two player game played on the positive integers. Players take turns choosing numbers and eliminating linear combinations of all numbers that have already been played. The player who is forced to choose the number “1” loses. In this talk, we will examine winning and losing positions in the Game of Sylver Coinage. Numerical semi-groups and directed graphs will be key tools in our investigation.
Charles Filippone  
Pikes Peak Community College  
Faculty Sponsor: Prof. Jennifer Holmes

*Unsolved Problems in Mathematics*

Mathematical problems range from propositions with proofs that must be rigorously examined to interesting conceptual puzzles. There are more mathematical problems that have been figured out than any point in past math history, with more solutions as time goes on, yet many important, long-standing ones are still unsolved. This talk looks at some of the most famous mathematical problems as well as lesser known ones, and what avenues may be required to finally crack them- if at all possible.

Tatiana Finley  
Colorado State University – Pueblo

*The Golden Section (aka the Golden Ratio)*

The universal ratio of beauty is the Golden Ratio, or Golden Section. This ratio is found in architecture, nature, music and art. This talk will discuss the history of the Golden Ratio, including some examples of its use from ancient civilizations to modern day, and its presence in natural structures.

Margaret Knight  
Colorado College  
Faculty Sponsors: Drs. David Talmy and Audra Hinson

*Viral Infection Rates of Micromonas Pusilla under Contrasting Nutrient and Light Conditions*

Phytoplankton play a central role in oceanic photosynthesis and form the basis of the marine food web. In recent years, an increased understanding of the prevalence of viruses in marine ecosystems revealed a need to study the role of viruses in the microbial loop. Existing systems model the viral infection dynamics of phytoplankton. However, the viability of these models requires assessment through comparison to data. We used the Metropolis-Hastings algorithm with experimental data to fit transfer affinity, lysis rate, susceptible host growth rate, infected host growth rate, control host growth rate, and burst size in our model system of ordinary differential equations. Two datasets were examined, which consider the host, Micromonas pusilla (Mp-LAC38), and the virus (MpV-08T) populations under contrasting nutrient and light conditions. Host and virus exposure to both nutrient limited and low light conditions resulted in increased transfer affinities and decreased lysis rates. However, limited nutrient conditions induced higher susceptible growth rates and burst sizes, while low light conditions showed opposite effects. This implies that the virus has greater success infecting the host under limited conditions, while the production of free viruses is slower. These findings can be used to assess nutrient cycling and carbon fixation within ecosystem models.

Samuel LeBlanc  
Colorado College  
Faculty Sponsor: Dr. Kirsten Hogenson

*Dispersable Book Embeddings of Cage Graphs*

In discrete mathematics, a graph is an abstract structure representing pairwise relationships (edges) between objects (vertices). A graph that can be drawn on a surface with no crossing edges is said to be embeddable on that surface. This talk examines graph embeddings on a unique type of surface, the book. Specifically, we explore the book embeddings of a family of highly symmetrical graphs, known as the cage graphs.

---

1 The faculty sponsors of this talk are affiliated with the National Institute for Mathematical and Biological Synthesis (NIMBioS), at the University of Tennessee.
Kristen Ochle & Heidi Staggs
Colorado State University – Pueblo

Math Mindsets for the Future

There is evidence that the mathematical mindset and attitudes that elementary teachers have about mathematics can carry over into their classroom instruction and affect their students’ mathematical mindsets, attitudes, and performance regarding the subject in the long term. In the course of our investigation of this problem, we found that some possible resolutions to these issues include elementary school teachers developing growth mindsets about mathematics, receiving a more thorough education in mathematics, and building confidence in their ability to teach mathematics. We will attempt to demonstrate how these solutions will improve the current status of education of elementary mathematics by discussing research articles in this area of interest and sharing what we believe is a better model for educating elementary students in mathematics.

Edgar Santos
Colorado College

Victor Neumann-Lara Biography and Dichromatic numbers of a Digraph

This talk attempts to break through Eurocentric mathematics and focuses on a non-European mathematician, Victor Neumann-Lara, who made incredible contributions to mathematics. Neumann was born in Hidalgo, Mexico in the year 1933 and completed his undergraduate, graduate, and postgraduate studies in mathematics from the National Autonomous University of Mexico by 1958. Neumann pioneered advances in discrete mathematics, graph theory, topology, and combinatorics, especially during the 1980s with his discovery of dichromatic numbers of a digraph in 1982. The dichromatic number of a digraph is the smallest number of colors needed to color the vertices on a digraph for there not to be a monochromatic directed cycle. By the time Neumann passed away in 2004, he had 63 publications, been cited over 587 times, taught hundreds of courses in universities across the world, and directed over 15 theses.

Lauren Stierman
Colorado College

A Mathematical Exploration of Strategies to Combat and Control the Zika Virus

Phytoplankton play a central role in oceanic photosynthesis and form the basis of the marine food web. In recent years, an increased understanding of the prevalence of viruses in marine ecosystems revealed a need to study the role of viruses in the microbial loop. Existing systems model the viral infection dynamics of phytoplankton. However, the viability of these models requires assessment through comparison to data. We used the Metropolis-Hastings algorithm with experimental data to fit transfer affinity, lysis rate, susceptible host growth rate, infected host growth rate, control host growth rate, and burst size in our model system of ordinary differential equations. Two datasets were examined, which consider the host, Micromonas pusilla (Mp-LAC38), and the virus (MpV-08T) populations under contrasting nutrient and light conditions. Host and virus exposure to both nutrient limited and low light conditions resulted in increased transfer affinities and decreased lysis rates. However, limited nutrient conditions induced higher susceptible growth rates and burst sizes, while low light conditions showed opposite effects. This implies that the virus has greater success infecting the host under limited conditions, while the production of free viruses is slower. These findings can be used to assess nutrient cycling and carbon fixation within ecosystem models.
Hudson Tompkins  
Western Colorado University  
Faculty Sponsor: Dr. Robert Cohen

*Patterns of Probability with Game Boards*

In this talk we will use various game boards and probability analysis to develop interesting patterns. These interesting patterns develop through sums of probabilities, expected values, and probability functions. Without the mechanics of the game board, these patterns would be difficult to discover and justify.

Christopher Toomey  
Colorado State University – Pueblo  
Faculty Sponsor: Dr. Rick Kreminski

*Proof of the Banach–Tarski Paradox*

The Banach-Tarski Paradox is a theorem which states the following: Given a solid ball in 3-dimensional space there exists a decomposition of the ball into a finite number of disjoint subsets which, using only translations and rotations, can then be put back together in a different way to yield two identical copies of the original ball. Pivotal to this proof is the axiom of choice. When introduced by Ernst Zermelo to formalize his proof of the well-ordering theorem the axiom was met with criticism. This theorem was used by some as an argument against it. However controversial at the time, the axiom is now used fairly frequently and this theorem is held as one of the most counterintuitive results in mathematics.

Jim Wang  
United States Air Force Academy  
Faculty Sponsor: Dr. Kurt Herzinger

*Exploring Roots of Higher Order Polynomials Through Expanded Greek Ladders*

Greek ladders are an ancient method of Diophantine approximation. Previous work in Greek ladders has focused on using techniques from linear algebra to approximate roots of quadratic polynomials. We attempt to extend this work to higher degree polynomials. In this talk, we will focus on constructing Greek ladders that approximate roots of cubic polynomials and the relationship to the eigenvalues of an associated 3x3 matrix.

Joshua Yauney  
United States Air Force Academy  
Faculty Sponsor: Dr. Kurt Herzinger

*Approximating Roots of Quadratics Using Greek Ladders*

A Greek ladder is an ancient algorithmic technique for approximating algebraic numbers with rational numbers. In this talk, we will examine the basics of Greek ladders for approximating √k. Then, we will demonstrate how to modify this technique for approximating roots of any quadratic. Our primary tool will be linear algebra with 2×2 matrices.
ACKNOWLEDGMENTS

The Conference Steering Committee gratefully acknowledge the generous support and assistance of the following individuals and organizations.

Rocky Mountain Section of the Mathematical Association of America
Dr. Alexander Hulpke, Chair
Dr. Mona Mocanasu, Secretary/Treasurer

Department of Mathematics and Physics, Colorado State University - Pueblo
Dr. Paul Chacon, Chair
Ms. Joleen Ryan, Administrative Assistant

Department of Mathematics, Colorado College
Dr. Andrea Bruder, Chair

Department of Mathematics, University of Colorado Colorado Springs
Dr. Zak Mesyan, Chair

Admissions Office, Colorado State University - Pueblo
Ms. Tiffany King, Director

A'viands Food Services at CSU Pueblo, Colorado State University - Pueblo
Mr. Jerry Carter, Director

Special thanks to:
Colorado State University Pueblo Local Organizing Committee Members:
Janet Heine Barnett, Rick Kremski, Frank Zizza

Ms. Joleen Ryan
Administrative Assistant
Department of Mathematics and Physics
Colorado State University - Pueblo

George W. Heine III, Math and Maps
PPRUMC 2020 Webmaster